NEWSLETTER

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Content

EMPIR 19ENV01 traceRadon: An introduction

Radon gas is the largest source of public exposure to naturally occurring radioactivity, and concentration maps based on atmospheric measurements aid developers to comply with EU Basic Safety Standard Regulations (EU-BSS). Radon can also be used as a tracer to evaluate dispersal models important for identifying successful greenhouse gas (GHG) mitigation strategies.

To increase the accuracy of both radiation protection measurements and those used for GHG modelling, traceability to SI units for radon release rates from soil, its concentration in the atmosphere and validated models for its dispersal are needed. This project will provide the necessary measurement infrastructure and use the data that this generates to apply the Radon Tracer Method (RTM) which is important for GHG emission estimates that support national reporting under the Paris Agreement on climate change. An overlapping need exists between the climate research and radiation protection communities for improved traceable low-level outdoor radon measurements, combining the challenges of collating and modelling large datasets, with setting up new radiation protection services.

Compared to the large spatiotemporal heterogeneity of GHG fluxes, radon is emitted almost homogeneously over ice-free land and has a negligible flux from oceans. Radon flux relates to the transfer process of radon activity from soil to the atmosphere per square metre and second, whilst radon activity concentration is the amount of activity of radon in the atmosphere per cubic metre. Atmospheric measurements of radon activity concentrations can be used for the assessment and improvement of atmospheric transport models (ATM). However, traceability to the environmental level does not currently exist for measurements of radon fluxes and atmospheric radon activity concentrations. Therefore, significant improvements in such measurements are needed. Climatic Atmospheric Monitoring Networks (AMN) like the European Integrated Carbon Observation System (ICOS), are infrastructures that operate GHG monitoring stations and include atmospheric radon monitors in their stations. The radon data produced from such networks can be used to improve transport modelling and the estimation of GHG emissions based on the RTM, which uses the correlation between GHG and radon concentrations. However, this radon data needs significant improvement in terms of the accuracy of both radon flux measurements and environmental radon activity concentrations in the range 1 Bq·m^{-3} to 100 Bq·m^{-3} to be able to provide robust data for use in the RTM. Similarly, for radiation monitoring, all European countries have installed networks of automatic radiation dose and airborne contamination monitoring stations and report the information gathered to the European Radiological Data Exchange Platform (EURDEP), thus supporting EU member states and the EURATOM treaty.

Currently, monitoring information on dose rates is collected from automatic surveillance systems in 39 countries, however, urgently needed data on outdoor radon activity concentrations is not yet collected due to a lack of ability to measure accurately at the low levels encountered in the environment. Furthermore, accurately detecting contamination from nuclear emergencies relies on rejecting false positive results based on radon washed from the atmosphere by rain. Therefore, improving contamination detection requires greater accuracy in determining environmental radon concentrations and their movement in the atmosphere.

At this point in time 18 partners and 12 collaborators are working toward this goal!

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

News from the work packages and recent developments

WP 1: Outdoor radon activity concentrations

Figure 2: Intercomparison setup at PTB Braunschweig site with ARMON detector and ANSTO 200 L detector, as well as intake air lines.

In the course of this work package two new ^{222}Rn emanation sources for primary calibration of ^{222}Rn activity concentration measurement devices traceable to SI were developed. They are meant for implementation at atmospheric monitoring network stations. In addition, two new transfer standards meant for secondary calibration were developed: the ARMON (UPC) and the ANSTO 200 L (ANSTO). To ensure stability and consistency of the two instruments short-term comparisons at two experimental sites were performed as a quality assurance procedure. A long-term comparison of 6 months was performed as well,

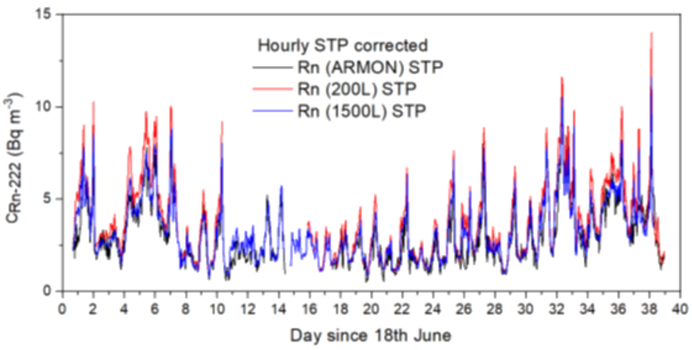

Figure 4: ^{222}Rn activity concentration in Bq·m^{-3} over time in days starting from 2022-06-18 measured at Saclay ICOS station by ARMON (black), ANSTO 200 L (red) and ANSTO 1500 L (blue) monitors, sampling air at 100 m a.g.l. height.

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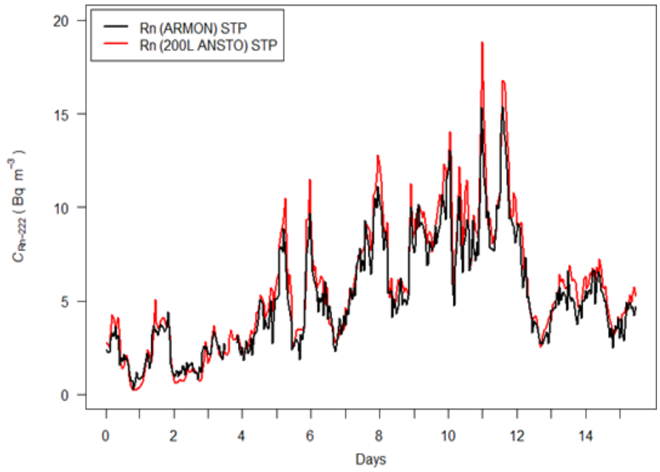

Figure 1: ^{222}Rn activity concentration in Bq·m^{-3} over time in days starting from 2022-11-29 measured at PTB by ARMON (black) and ANSTO 200 L (red) monitors.

and data analysis is in the final stage. Here, the short-term intercomparisons are presented.
The first site chosen for the short-term intercomparison was the reference free field of PTB Braunschweig, Germany. It was conducted during November and December 2021. Both instruments were set inside a shelter to protect them from external weather conditions (see Figure 2), sampling air at a height of 1 m above ground level (a.g.l.) on the outside reference free field. A photograph of the inside of the shelter is shown in Figure 2. The ^{222}Rn activity concentration recorded at PTB is presented in Figure 1

Figure 3: Shelter at Saclay with three ANSTO detectors.

The second site chosen was the Saclay ICOS atmospheric monitoring network station, located 20 km southwest from Paris, France. At Saclay station, the two transfer standard instruments were compared with the ANSTO 1500 L radon monitor existing at the station, sampling air at 100 m a.g.l. during June and July 2022. The ^{222}Rn activity concentration recorded by the three monitors is presented in Figure 4. Figure 3 shows a picture of the shelter with the ANSTO 200 L and the ANSTO 1500 L implemented for the long-term comparison.

The ^{222}Rn activity concentration measurements in $Bq \cdot m^{-3}$ of the ARMON (black) and the ANSTO 200 L (red) over several days are shown. Measurements of the existing ANSTO 1500 L device at Saclay are added in blue. The presented measurements were recorded from 2021-11-29 to 2021-12-16 in Figure 1 and from 2022-06-18 to 2022-08-26 in Figure 4, respectively.
The mean ^{222}Rn activity concentration measured at Saclay is $(3.1 \pm 1.7)\ Bq \cdot m^{-3}$ for the ARMON and $(3.8 \pm 2.1)\ Bq \cdot m^{-3}$ for the ANSTO 200 L, much smaller than the mean value of the ^{222}Rn activity concentration measured at PTB ($(5.2 \pm 3.0)\ Bq \cdot m^{-3}$ for the ARMON and $(5.7 \pm 3.4)\ Bq \cdot m^{-3}$ for the ANSTO 200 L). This is to be expected, as at Saclay the air was sampled at 100 m a.g.l. height and at PTB at a height of 1 m a.g.l. Also, the ^{222}Rn activity concentration varies with season and is smaller in summer, than in late autumn [1]. Overall, the data of the ARMON and the ANSTO 200 L are in good agreement at Saclay and PTB.
The mean difference ($C_{ANSTO\ 200\ L} - C_{ARMON}$) of the two measurements at PTB amounts to $(0.5 \pm 0.8)\ Bq \cdot m^{-3}$ and at Saclay to $(0.7 \pm 0.9)\ Bq \cdot m^{-3}$. In the ideal case of identical ^{222}Rn activity concentration measured by both devices the mean of ($C_{ANSTO} - C_{ARMON}$) would amount to 0. This is the case within the statistical standard deviation at Saclay and PTB both, indicating that the values measured by the two devices are identical within the statistical standard deviation.
Altogether, the ANSTO 200 L measured slightly higher ^{222}Rn activity concentrations than the ARMON. Further investigations on the possible reasons, including questions regarding the exact calibration factor of the ARMON at PTB, are planned.
The two detectors measure identical ^{222}Rn activity concentrations within the statistical standard deviation. This holds true, even though there were several months between the measurements, the two detectors had undergone the ordeal of being transported from Braunschweig, Germany, to Saclay, France, (roughly 900 km) and the measurement conditions were vastly different (different ^{222}Rn activity concentration, different temperature, different season, ...). Therefore, we consider both instruments suitable as transfer standard.
Additionally, the ARMON transfer standard was compared to the Heidelberg Radon Monitor (HRM) from Heidelberg University at Saclay, both sampling air at 60 m a.g.l. (see Figure 5) during February and March 2021.
From Figure 5, the mean ^{222}Rn activity concentration measured is $(2.7 \pm 1.9)\ Bq \cdot m^{-3}$ for the ARMON and $(2.4 \pm 1.8)\ Bq \cdot m^{-3}$ for the HRM.

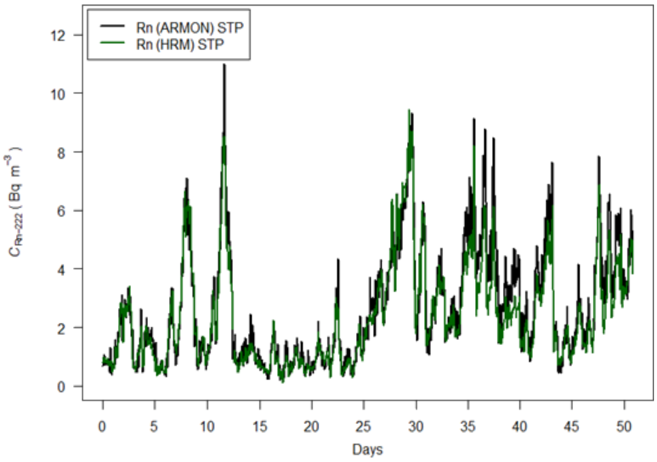

Figure 5: ^{222}Rn activity concentration in $Bq\ m^{-3}$ over time in days starting from 2022-02-01 measured at Saclay ICOS station by ARMON (black) and HRM (green), sampling air at 60 m a.g.l.

WP 2: Radon flux measurements

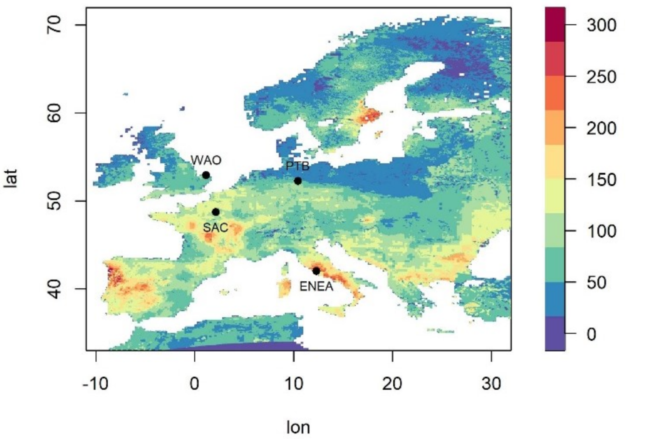

Figure 6: Radon flux map calculated for June 2020 (based on GLDAS-Noah v2.1) and locations of traceRadon sites.

Three radon flux measurements campaigns have been realized between November 2021 and September 2022 at ENEA (Italy), PTB (Germany) and SAC (France) sites, see Figure 6. Each campaign lasted around 3-4 months. 3-hourly radon flux measurements were carried out using an Autoflux ANSTO system (Figure 7) which was previously characterized and calibrated using a reference exhalation bed (Task 2.1, [2]) and then compared with other radon flux systems (Task 2.2, [3]).

Figure 7: Autoflux ANSTO system.

Figure 8: Set-up of intense radon flux campaigns carried out at PTB (Germany).

At each site, together with the radon flux from the soil surface, were also measured: the environmental gamma dose rate, environmental parameters (temperature, water soil content, pressure, accumulated rain, etc.), the activity of the radionuclides (^{226}Ra, ^{40}K, etc.) in the soil and the physical parameters of the soil (porosity, bulk density, etc.). In addition, gamma spectrometry was continuously performed at 1 m above the ground level. Figure 8 shows a typical campaign set-up (PTB site).

Figure 9 shows the time series of the 3-hourly radon flux measured at the PTB site from November 2021 to January 2022. Measurements were realized using an automatic radon flux measurement system indicated here as Autoflux. The system was designed and built by the Australian Nuclear Science and Technology (ANSTO). This new system was improved in collaboration with the Universitat Politècnica de Catalunya (UPC). Then, the Autoflux was characterized and calibrated by UPC in collaboration with Universidad de Cantabria [2]. In addition, UPC implemented the remote control of the system for data download during the experiments.

The Autoflux system allows measurements of the radon flux from the soil surface every 3 hours. The system includes an AG PQ2000 PRO (Saphymo) radon monitor, an accumulation chamber with an automatic opening and several environmental sensors. Sensors are installed, during the measurements, both in the soil and at 50 cm above the ground. The radon flux can be calculated using the slope of the radon concentration measured within the chamber during the accumulation phase (1 h). The following 2 h are used to ventilate the chamber and to reduce the radon concentration inside the volume.

Radon flux observations were compared with radon flux values obtained applying available models, for more details see Figure 12.

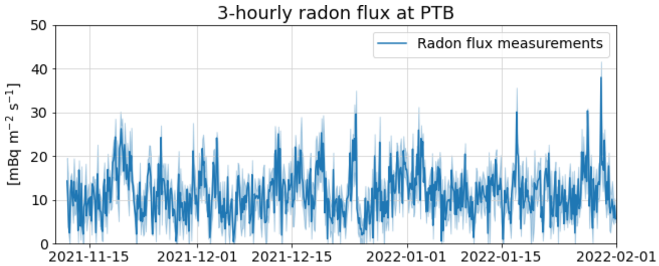

Figure 9: Time series of 3-hourly radon flux observation measured at PTB from November 2021 to January 2022.

In the frame of one activity, a first sensitivity study of the parameters influencing the application of the Radon Tracer Method (RTM) was performed at the Saclay ICOS (Integrated Carbon Observation System) station. Saclay (SAC) is located 20 km south-west of Paris (lat: 48.7217 °N, long: 2.142 °E, 160 m above sea level).
A python code was prepared for the RTM application, and it is hosted on the ICOS Carbon Portal (CP) JupyterHub. This was done to take advantage of the ICOS CP python package to access the ICOS sites data and the pre-calculated sites footprints. By default, the code uses the footprints already calculated without radon decay contribution by the Lagrangian model STILT as configured on the CP (available for all ICOS sites and more for at least 2018 to 2020). The radon exhalation maps used are either the INGOS one [4] which is a climatology over 2006-2016 with one value per month or the two new maps developed in the project traceRadon. The code applies the RTM on the concentration data measured between 21:00 UTC and 06:00 UTC. This temporal window was selected because it is a nighttime period for most sites in northern Europe. For the sensitivity study here, the possibility of using radon and greenhouse gas data from the available csv files was also added. In addition, the option to use footprints calculated with other models was made possible. Thus, footprints calculated using the FLEXPART model (UPC) as well as by the NAME model (UK) were also used. The exercise was performed for data measured in February 2019 and August 2019. Figure 10 shows the nocturnal CO_2 fluxes

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obtained applying the RTM with the different radon flux information and footprints.

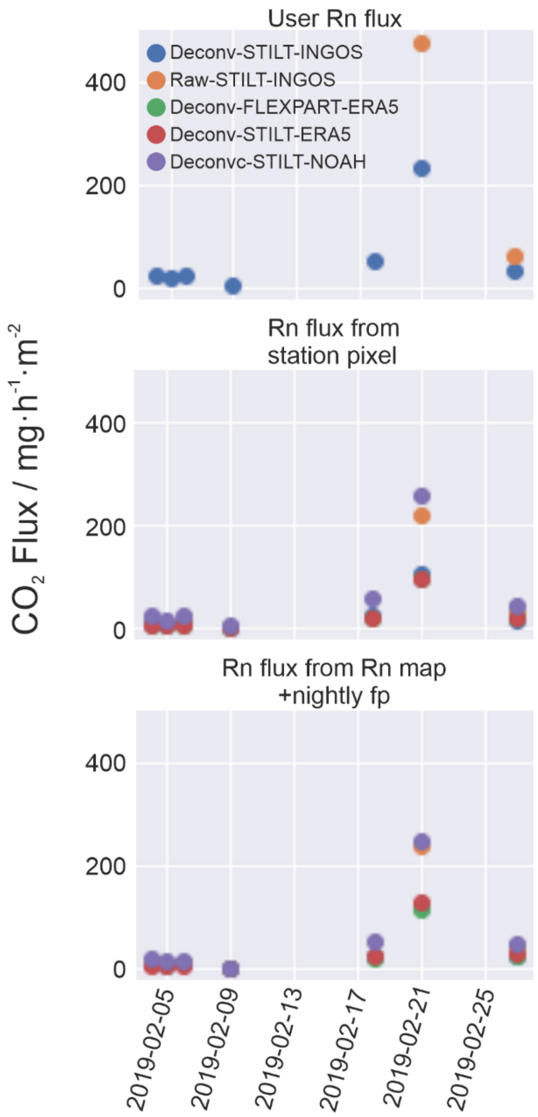

Figure 10: CO_2 fluxes calculated with the RTM at Saclay in February 2019 for the different configurations.

WP 3: Radon flux models and inventories

European radon flux maps based on different approaches are compared in the traceRadon project. The radon flux models are either using parameterizations of radon emanation and transport in the soil or exploiting the correlation between gamma dose rate and radon flux.

A process-based radon flux model is applied to calculate European radon flux maps using soil parameter maps as well as spatially and temporally resolved soil moisture reanalysis datasets (ERA5-Land and GLDAS-Noah v2.1). An example of the modelled radon flux for June 2020 (based on GLDAS-Noah v2.1) is shown as background map in Figure 12. Monthly and daily radon flux maps for 2007-2021 and 2017-2021 are provided for application of the Radon Tracer Method and in atmospheric transport modelling studies. On seasonal time scales soil moisture appears to be the main factor determining the temporal variations of the radon flux, with high soil moisture limiting the radon diffusion in the soil. Figure 11 shows multi-year mean monthly radon fluxes for the European continent based on the current soil moisture reanalyses (ERA5-Land and GLDAS Noah v2.1) in comparison with previous versions (ERA-Interim/Land and GLDAS-Noah v1.0 used in [4]).

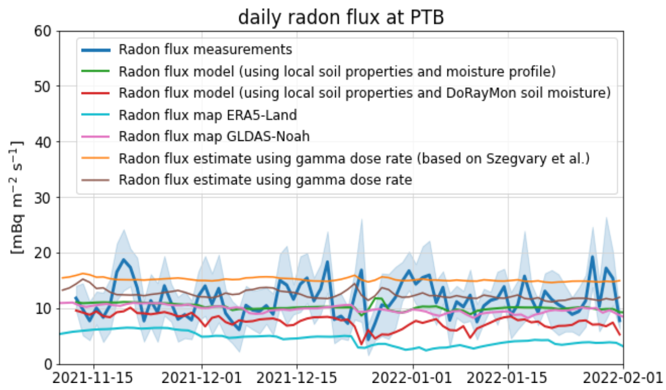

Figure 12: Comparison of daily mean radon flux measurements at PTB with different model results. The shaded area represents the standard deviation of the 3-hourly measurements around the daily mean.

Also included in the comparison are monthly fluxes from other published maps based on a similar process-based model [5] and based on gamma dose rate measurements [6]. The differences in the absolute radon flux and the seasonal amplitude emphasize the importance of systematic validation of radon fluxes, but also soil moisture input, by comparison with representative observations.

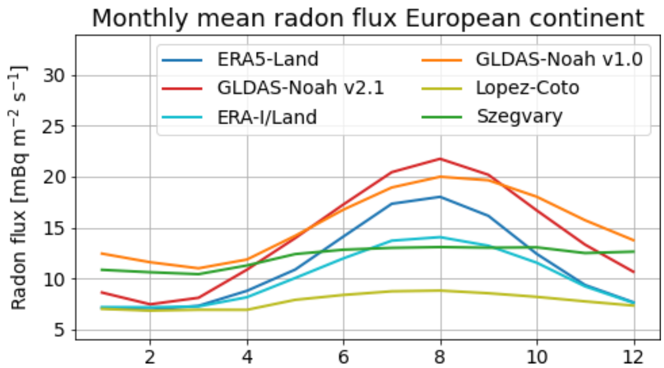

Figure 11: Mean monthly radon flux estimates for the European continent based on different model approaches.

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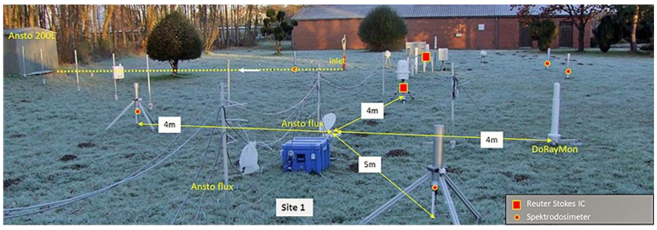

Figure 13: Photograph of the PTB site with the installed instruments used in the long-term campaign.

The intensive measurement campaigns provide a first basis to evaluate the physical parameterizations and performance of current process-based radon flux model as well as the gamma dose rate based approach on short time scales. Daily mean radon fluxes computed with the process-based model using measured radium activity, soil properties together with direct measurements of soil moisture profiles or with soil moisture estimated from gamma spectra (DoRayMon measurements, c.f. next paragraph) as well as radon fluxes estimated from gamma dose rate measurements according to the approach of [6] are compared to radon flux measurements at PTB in Figure 11. Radon fluxes extracted from the European radon flux maps are also included. All soil moisture-based model results show much less day-to-day variability compared to the measurements, indicating that other processes not fully represented in the model become more important on shorter timescales of hours or days.

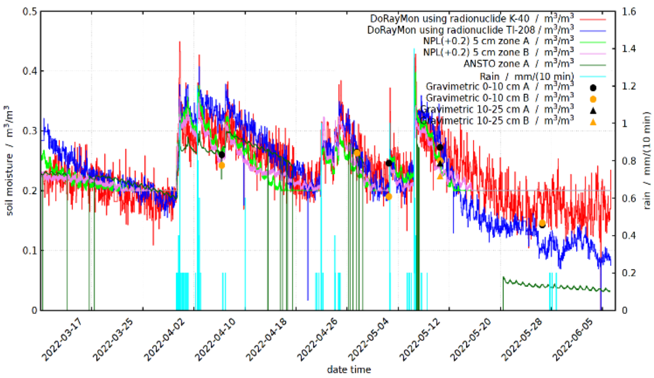

Figure 14: Results of soil water content by using the spectrometric detectors (^{40}K and ^{208}Tl), continuous sensors and gravimetric measurement at ENEA site.

Soil water content is a crucial parameter to estimate the radon flux by using models. It is also very helpful in other application such as in the agriculture. Therefore, a good characterization of soil water content is needed. Different methods to measure or calculate it have been used. In the project, besides the use of continuous sensors and gravimetric measurements, the gamma-spectrometry methodology [7] has been developed and is currently being used in the long-term campaigns carried out at 4 sites defined in the project. The spectrometry system, based on a NaI detector of 50 mm · 50 mm, was used for the soil water content calculation named DoRayMon. In Figure 13, a photograph of the detectors installed at PTB-Braunschweig site, including DoRayMon, is shown. In Figure 14, the results at ENEA site, as an example, show that the spectrometry methodology can determine the variations of the soil water content and seems to be more robust than the sensors. The increase of the number of spectrometric detectors installed in the national networks could be potentially used for estimating continuously the soil water content in large areas.

WP 4: Radon and radon flux in maps

Outdoor radon, radon flux and Radon Priority Areas:
According to the European Council directive 2013/59/Euratom Member States need to identify areas - often called “radon priority areas -RPA”, where specific radon protection measures should be applied, e.g. mandatory radon measurements in work places in basement and ground floor. To identify those areas, the Geogenic Radon Potential can be used, and the concept of the Geogenic Radon Hazard Index (GRHI) was developed and discussed in the last years, especially in the MetroRadon project (http://www.metroRadon.eu/). Within traceRadon the GRHI methods are reviewed and further developed and especially the usability of outdoor radon activity concentration data and radon flux data is evaluated.
For the GRHI in principle two approaches exist: a) Supervised learning techniques, where a regression model predicts radon concentrations (indoor or in soil gas) using multivariant input data and b) unsupervised learning techniques, where structures in data sets are investigated and multiple variables are combined to generate a metric, which is a proxy for Radon risk (e.g. dimensionality reduction).
For the purpose of improvement of the GRHI the collection of a European data set for possibly relevant input data (e.g. geogenic maps, radionuclide concentration in soil, terrain, weather, outdoor radon and radon flux) for the GRHI is ongoing and a consolidated data set will be developed. In addition, the newly obtained outdoor and Rn flux data within traceRadon activities will be evaluated for integration in the GRHI.

Concerning outdoor radon, national data sets exist at the time only in few countries in Europe (e.g. Belgium, Germany). Therefore, the evaluation of usability of this data for improvement of the GRHI will be tested in these selected countries as a first step.

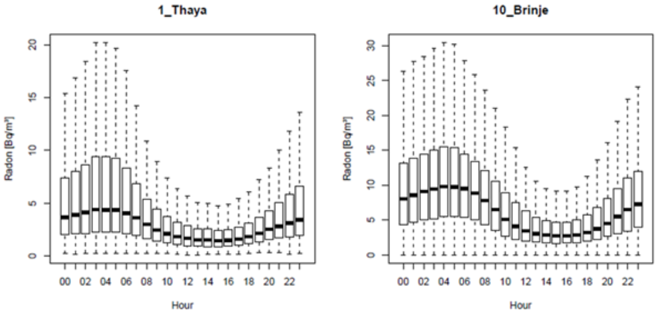

Figure 15: Diurnal variations of outdoor Radon concentrations at two aerosol monitoring stations in Austria.

Outdoor radon concentration shows durinal and annual variations and correlates mainly with geogenic factors (e.g. lithology, permeability), meteorological data, terrain and distance to the ocean. The correlation with indoor radon can be weak to strong. These effects are reported in literature, summarised in a paper of this project [1]. The variability of outdoor radon concentration data and correlations with different parameters is studied also on test data sets collected and made available for the project (Figure 15).

Regarding radon flux measurements and radon flux maps a literature review on the use of on the prediction of the RPAs has been conducted.

Different factors influencing radon flux have been investigated through the literature survey. Due to complex dependence of various factors, it is difficult to quantify their contribution to radon flux. Several different methods and measuring devices were used for radon flux measurements making it difficult to compare results and thus harmonization of different measurement methods is needed and measurement protocols should be well defined. Radon flux measurements are challenging to perform and thus measurements were performed at much smaller scale compared to indoor radon surveys. Only one national survey of radon flux measurements was identified in literature survey, covering 111 locations in Japan. Radon flux maps were produced from only a few measurements campaign. These maps could be used as an input parameter for the estimation of RPAs. However, these maps were produced at very low density compared to maps based on indoor radon concentrations and thus it is not clear to what extent these values could be considered representative. Therefore, to use radon flux data for radiation protection purposes, radon flux surveys should be performed more systematically and at a larger scale.

In several studies, radon flux was correlated with other "radon quantities" such as: indoor radon, ^{226}Ra content in soil, gamma dose rate. Relatively high correlations between radon flux and ^{226}Ra in soil as well as between radon flux and gamma dose rate, indicate that the above mentioned quantities could be considered as good proxies for radon flux estimation. In another survey, large variations of ^{226}Ra content in soil were measured, but small variations of radon flux and vice versa. Results indicate that additional quantities should be used for indoor radon or radon flux predictions.

Radon flux models were derived to be used as environmental tracer for atmospheric processes and for radiation protection purposes. First radon flux models were very simple, assuming constant value across the globe or depending only on the latitude. In just a few decades, models became more advanced using ^{226}Ra activity concentration in soil or terrestrial gamma dose rate with detailed additional databases of soil and meteorological parameters. A state-of-the-art radon flux map of Europe, modelled by [4] has achieved spatial resolution of 0.083° · 0.083° and temporal resolution of one month, and it is going to be further improved within the traceRadon project.

A paper reporting the full results of the literature review is in preparation, we keep you informed!

Past Events

Direct input to standard developing organizations (ISO and IEC) was generated as well as to working groups related to regulatory issues. Recent research outputs and new developments in the project are disseminated to the scientific communities via conferences, publications and workshops.

ICRM-LLRMT 2022

The ICRM working group for Low-Level Measurements Techniques (LLMT) examines techniques to enable the detection of ever lower amounts of radioactivity. The working group focuses on metrology and the latest developments in a variety of areas, including measurement of environmental radioactivity, radionuclides in food and drinking water, reference materials characterisation, tracer studies and nuclear physics research. The newly developed low-level radon sources on were in the focus of interest the conference.

EURAMET GA 2022

The Technical Committee for Ionising Radiation (TC-IR) is concerned with the metrology of ionising radiation related to medical, industrial, environmental, scientific and radiation protection applications. During the GA of EURAMET the advances of traceRadon were presented by the TC-IR Chair in May 2022.

IRPA 2022

On 4th June 2022, the 6th European IRPA Congress came to an end. Nearly 450 radiation protection professionals met and shared their results and started discussions on 14 topics.

Figure 16: As the coordinator, Annette Röttger was happy to meet several colleagues from the consortium face to face for the first time since two years. Aside from a lot of scientific discussions and future planning's, she received special thanks from Dr. Gémesi Zoltán for her support of the Hungarian research activities.

With one oral presentation and two poster presentations the consortium was able to support the radiation protection community with new results in research and new customer services: The oral presentation summarized the possibility for "Exploitation of results: Radon metrology for the use in climate change observation and radiation protection" while the posters gave details on calibration processes and new data achieved in field measurements.

Hungary has joined ICOS in 2021: https://www.icos-cp.eu/event/1069

EGU 2022

EGU General Assembly 2022 brings together geoscientists from all over the world to one meeting covering all disciplines of the Earth, planetary, and space sciences. In the session of Geosciences Instrumentation & Data Systems the topic Geoscience applications of environmental radioactivity was addressed by a highlighted presentation on radon metrology for use in climate change observation and radiation protection at the environmental level in May 2022.

EURADOS AM 2022

The European Radiation Dosimetry Group (EURADOS) is a network of 81 European institutions (Voting Members) and more than 600 scientists (Associate Members). A number of presentations dealing with the results of traceRadon were given in the WG3 of EURADOS in June 2022.

Newest Publications

1. Radulescu, I et al.: Inter-comparison of commercial continuous radon monitors responses, Nuclear Instruments and Methods in Physics Research Section A, Volume 1021, 2022, 165927, https://doi.org/10.1016/j.nima.2021.165927
2. Mertes, F. et. al.: Ion implantation of ^{226}Ra for a primary ^{222}Rn emanation standard, Applied Radiation and Isotopes, Volume 181, March 2022, 110093, https://doi.org/10.1016/j.apradiso.2021.110093
3. Čeliković, I. et. al.: Outdoor Radon as a Tool to Estimate Radon Priority Areas - A Literature Overview, Int. J. Environ. Res. Public Health 2022, 19, 662, https://doi.org/10.3390/ijerph19020662
4. Mertes, F et. al.: Development of 222Rn emanation sources with integrated quasi 2π active monitoring, Int. J. Environ. Res. Public Health 2022, 19, 840, https://doi.org/10.3390/ijerph19020840
5. Rábago, D. et al.: Intercomparison of Radon Flux Monitors at Low and at High Radium Content Areas under Field Conditions, Int. J. Environ. Res. Public Health 2022, 19, 4213, https://doi.org/10.3390/ijerph19074213
6. Röttger, S. et al: Radon metrology for use in climate change observation and radiation protection at the environmental level, Adv. Geosci., 57, 37–47, 2022, https://doi.org/10.5194/adgeo-57-37-2022
7. Chambers, S. et al: Portable two-filter dual-flow-loop 222Rn detector: stand-alone monitor and calibration transfer device, Adv. Geosci., 57, 63–80, 2022, https://doi.org/10.5194/adgeo-57-63-2022

Upcoming Events

Staying in touch with the project is easy: Just follow us on twitter: @traceRadon:

https://twitter.com/traceradon

A website is available at
http://traceradon-empir.eu/

A notice board was established on
https://www.researchgate.net/project/19ENV01-traceRadon
as well.

The consortium is currently preparing to contribute to the following meetings, conferences or workshops:

September 2022	ICOS Science Conference 2022
September 2022	WMO-BIPM Workshop on Measurement Challenges for Global Observation Systems for Climate Change Monitoring
September 2022	M27 Meeting
November 2022	16th biennial conference of the South Pacific Environmental Radioactivity Association (SPERA)
November 2022	Cape Grim Annual Science Meeting
March 2023	ICRM 2023

Acknowledgements

EMPIR 19ENV01 traceRadon was launched in summer 2020. It is supported by a broad global scientific community within climate research, radiation protection and metrology. All stakeholders are united by the goal of providing new and improved data for science, the public and decision makers.
In the preparation of the project, the communication and discussion within EURADOS WG3 turned out to be very effective. Further thanks go to EURAMET e.V., the European Association of National Metrology Institutes which made such a project possible within the EMPIR framework program.

For the time being, the project traceRadon has established the following collaborations by a Letter of Agreement (in the order of signature date): Collaborators by signed letters of agreement:

1. Universität Heidelberg, Germany
2. ANSTO, Australia's Nuclear Science and Technology Organisation, Australia
3. ERA, European Radon Association, Europe
4. Met Office, United Kingdom
5. University of Novi Sad, Serbia
6. Politecnico di Milano, Italy
7. University of Codoba, Spain
8. EURADOS, e.V., Europe
9. Universität Siegen, Germany
10. IRSN, France
11. ARPA Piemonte, Italy
12. ARPA Valle d'Aosta, Italy
13. LIFE-Respire
14. Peter Bossew

The consortium is grateful to have this powerful support from colleagues worldwide! Further collaboration interest is welcome.

This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. 19ENV01 traceRadon denotes the EMPIR project reference.

References

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